Clinical Update

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Determining Implant Stability

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Introduction

Implants revolutionized dentistry and provide a viable treatment modality in the replacement of missing or un-restorable teeth. Long-term implant survival rates are reported in a range from 85-99%[1] and can be influenced by several elements including healing time, implant surfaces characteristics, bone quality and surgical and restorative techniques. Classic guidelines used to enhance successful implant therapy include an unloaded healing period of 3 to 6 months to promote osseointegration, which is defined as the bone to implant contact at the light microscopic level.[2,3] However, patients today would like the treatment and healing time shortened to allow for immediate provisionalization and an earlier restoration.

There are several surgical objectives that are thought to be important in accelerating the healing process of osseointegration. One of the more important of these objectives is to achieve initial primary stability. The torque value at time of placement is one indicator of determining initial stability. The literature shows that at a minimum, insertion torque of 20Ncm led to higher success rates.[4,5] In addition, the initial torque value has been used to determine if an implant can be single-staged by placing a healing abutment/ provisional at the time of surgery or if the implant needs to be submerged and allowed to heal for a longer period. It is prudent, therefore, to ensure that the implant is clinically stable prior to the restorative phase. Several clinical tests can be used to determine stability and are used as indicators of osseointegration, however most are only gross subjective measuring techniques.

Determinants and Tests of Implant Stability

Implant stability can be simply stated as the absence of clinical mobility. Initial implant stability is determined by two factors. The first is the quality of the bone where the implant is being placed (cancellous- less dense vs cortical- denser). The second factor is the degree at which the implant engages the bone. This is influenced by the type of bone as described above along with the design of the implant threads and the implant surface characteristics. It is also directly related to the surgical technique during placement. At the time of implant placement, the bone quality is assessed by the surgeon. In less dense bone, the surgeon may opt to undersize the osteotomy, potentially maximizing the initial bone-to-implant contact and implant stability. The last determinant of implant stability is how the bone heals around the implant.

Once an implant is placed and restored into function, it is subject to loads in axial, lateral and rotational directions. When testing implant stability, different tests are used depending on the direction of the load that is being evaluated.

Albrektsson used mobility as one of the criteria to determine stability and success[6]. While there are different indexes to assess mobility, the ability to visually detect and measure clinical mobility is difficult, and is more subjective in nature. Typically, mobility is determined by applying lateral pressure, using the end of two mirrors, and a visual estimate of the distance of movement in one direction is noted. The observation of clinical implant mobility utilizing this technique only grossly measures mobility and signifies implant failure either at the surgical stage or post healing. This technique is not sensitive enough to allow for making better clinical decisions for determining appropriate healing periods post-placement and may lead to restoring an implant after what is thought to be successful osseointegration.

Another non-invasive way to check the stability of a healed implant is the percussion test. The percussion test uses the blunt end of a mirror handle which is tapped on the implant or restoration in the axial direction. A stable implant will sound similar to that of an ankylosed tooth. The downfall of this test is that it cannot be standardized from one provider to another and that it can only identify a failed implant, not one that may have achieved only partial osseointegration or is in the process of failing. Similar to testing for lateral mobility after healing, this technique could lead to a definitive restoration being delivered on a poor foundation, costing time and money to the patient.

Torque testing is more commonly utilized to determine stability both at the time of implant placement or following healing. However, this technique is time consuming and is a difficult process. At the time of implant placement, torque values are measured utilizing a hand-held torque wrench or the hand piece unit. Most handheld wrench markings indicate larger increments between torque values, making the accurate assessment difficult. Utilizing the hand piece unit can provide a more accurate assessment of torque values at implant placement. However, this is time consuming as one must incrementally dial the torque forces on the unit multiple times once the implant is seated to determine the final seating torque at implant placement. This technique cannot be used to monitor osseointegration over the healing period as micro-motion during the early healing phase can play a negative role in osseointegration.[7]

Following healing, the reverse-torque test can be utilized to determine stability/osseointegration. During this test, a set reverse torque value is applied to the implant at any time after a period of healing, typically during the final impression visit. Sullivan in 1996 determined that using a reverse torque of 20Ncm provided a safe and reliable method to confirm that an implant is osseointegrated.[4] Ideally, during this test, the implant will not rotate. However, the invasive nature of this test may not allow for implants that are healing slowly to fully integrate, and may not detect partial integration or failing implants.

Resonance Frequency Analysis

Until recently there has not been developed a reliable, efficient and non-invasive technique to objectively test implant stability however, with the development of resonance frequency analysis (RFA) a more sensitive, objective and non-invasive way to measure implant stability can be achieved. RFA has been researched for 15 years and has recently been used clinically. RFA is a test that sends a frequency through a transducer attached to the implant that applies a fixed lateral force to the implant and measures its displacement, simulating a clinically loaded implant.[8]

The Osstell company has produced an instrument (Osstell ISQ) designed to measure a proprietary measurement called "implant stability quotient" (ISQ). ISQ evaluates the stability of the implant by measuring the stiffness of interface between the implant and bone.[8] Publications recommended surgical and restorative protocols based on over 500 studies can help providers in making clinical decisions

and provide for better communication between the surgeon and restorative dentist. (Fig. 1) RFA has been able to objectively show a different implant stiffness when comparing initial and post healing ISQ values indicating osseointegration and has been able to detect failing implants prior to clinical mobility.[9] In addition, ISQ values were significantly positively correlated to initial torque values in determining stability at 6 weeks. [10, 11]

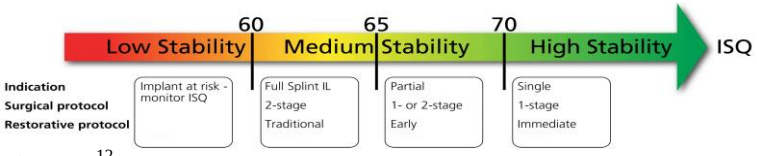

Figure 1[12]

RFA Clinical Applications

There are several different clinical applications where the use of RFA can provide objective data to help the practitioner make clinical decisions. The most common application of RFA in the clinical environment is during implant placement and at either the uncovering surgery or the final impression appointment. The single ISQ value at the time of placement is helpful in determining loading protocols i.e. single versus two-stage or immediate provisionalization. A single ISQ value does not accurately predict implant survival. However, a second ISQ value ≥60 obtained just prior to the prosthetic phase of treatment has demonstrated implant survival according to one prospective study.[10]

Several other studies used ISQ values to make clinical decisions that ultimately altered the clinical outcome. In one study, ISQ values were measured at several points in time. Thirty-two of the forty implants were deemed successful after 6-weeks of healing with similar ISQ values recorded at implant placement and at 6-weeks. For the other eight implants, a decrease in ISQ was recorded and clinically the patients reported pain. These implants were allowed to heal an additional 8 weeks and were eventually restored successfully.[11] RFA can also be used to rescue a failing implant. A study by Vanden Bogaerde used RFA to determine that an implant was failing by witnessing a decrease from the initial ISQ of 67 to 53 at 6-weeks. The implant was unloaded and allowed to heal, and at 6 months the ISQ value was recorded at 72.[13]

Another application of RFA is early detection of implant failure. Friberg compared the initial ISQ values to the six-week postoperative values of 75 one-stage implants and noted a significant decrease in one implant. Although this implant exhibited no clinical mobility at the six-week appointment, several weeks later that implant became mobile and was considered a failure.[9] This study highlights how RFA, through non-invasive means, can be used to detect and monitor a failing implant.

These articles demonstrate that using RFA can accurately identify positive and negative implant healing trends and ultimately determine overall implant stability. In addition, ISQ values have shown similar diagnostic predictability as compared to initial torque values at 6 weeks post placement, potentially reducing negative influences of micro- movement during early healing.

Conclusion

RFA can provide an objective value to measure implant stability. The ISQ values can quantitatively measure implant stability in a non-invasive manner which can be consistently recorded for a specific implant and shared between providers significantly reducing both intra- and inter-provider error utilizing other techniques. ISQ values cannot be standardized between different implants but rather for the same implant over the healing period. The ISQ values are another tool we can use in our armamentarium to better monitor healing and detect complications with regard to implant therapy and aid in making treatment decisions allowing for early interventions which can lead to increased implant success and ultimately patient benefit.

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